SURFACE WATER STATION DESCRIPTION
TEXAS SPRINGS IN FURNACE CREEK WASH - 362727116501401
DEATH VALLEY NATIONAL PARK, CA.

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Updated by: Christine Gable Date: 08/16/2007
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(For WY2006 Only)

All figures referenced in this report are located in the Appendix.

LOCATION

The gaging station (station) at Texas Springs in Death Valley National Park (DEVA) is located at N 36° 27' 27" and W 116° 50' 14" in Inyo County, California, NW ¼ NW ¼ NE ¼ of Section 23, T. 27 N., R. 1 E. within Hydrologic Unit 18090203.

ACCESS

The park is 2.5 hours northwest from Las Vegas, Nevada (NV). Texas Springs is located off Highway 190, just southeast of the Furnace Creek Ranch in DEVA, California. To get to Texas Springs from Las Vegas, NV take State Route SR-160 to Pahrump, NV for 57 miles (traveling northwest). Turn left (west) on Bell Vista Road and travel 26 miles. (Bell Vista Road becomes State Line Road.) Turn right (north) on to State Route 127 and travel 0.2 miles. Turn left (west) on to SR-190 and travel 30 miles (**Figure 1**).

To access the station, turn east into the Texas Springs Campground before reaching the Furnace Creek Ranch. Travel 0.43 miles, then turn east on a gated dirt service road. The Texas Springs station is located approximately 1.1 miles east on this road (**Figure 2**). A high clearance vehicle is recommended. Water in the springs is considered non-potable.

Access inside the Texas Springs Tunnel is **not** permitted.

NOTIFICATION

Prior to visiting the station check in with the park hydrologist for DEVA (see Local Park Partner).

ESTABLISHMENT

The NPS established the station in 1978 to monitor the discharge of Texas Springs to identify trends in spring flow, and detect the effects of ground-water pumping on flow over time.

In 1989, a monitoring program was agreed to between the Barrick Bullfrog gold mine and the NPS as a condition attached to several water right permits. The monitoring plan included measurement of ground-water production and quarterly water levels in several monitoring wells by the mine, and monitoring the discharge of selected springs (Texas, Travertine and Nevares) by the NPS. In June, 2001 Barrick Bullfrog, Inc. closed their mining operation and transferred ownership of the monitoring wells to the United States Geological Survey (USGS). Water level monitoring continues informally by the USGS.

In 1991, a monitoring program was agreed to between NPS and the U.S. Department of Energy (DOE) to address NPS concerns regarding proposed ground-water production by DOE upgradient of DEVA and Devils Hole. The monitoring program is comprised of a network of springs and wells in the Yucca Mountain region of southern Nevada. Water production by DOE, water levels in wells and spring discharge are reported on a quarterly basis. The monitoring program includes water level monitoring at Devils Hole and discharge monitoring at Texas Springs by NPS. This program is ongoing.

ELEVATION

The elevation of Texas Springs is estimated to be 380 feet above sea level (USGS 7.5 minute topographic Quadrangle, Furnace Creek, CA. Provisional edition 1988).

DRAINAGE AREA

The Death Valley ground-water flow system encompasses an area of about 15,800 mi^2 (Harrill and others 1988).

HYDROLOGIC CONDITIONS

Death Valley is located at the terminus of a vast regional ground-water flow system in the Basin and Range physiographic province. The primary aquifer types within the regional flow system are Paleozoic carbonate rock, Tertiary volcanic rock and Cenozoic valley-fill aquifers. The carbonate rock aquifer is the principal regional aquifer within the Death Valley ground-water flow system. Ground water moves generally from recharge areas at higher elevations in the north to lower elevation valleys in the south, and ultimately to Death Valley. Because of the immense size and complexity of the flow system, it is often divided into subregions, and the subregions are further divided into ground water basins and sections.

The Alkali-Flat Furnace Creek basin is one of three ground-water basins within the Central Death Valley subregion. Discharge from this basin occurs at the springs in the Furnace Creek area including Texas, Travertine and Nevares Springs. These three springs appear to be related to a major fault zone known as the Furnace Creek fault zone. Low permeability material along the Furnace Creek fault zone may form barriers to flow causing ground water to flow upwards through Tertiary lacustrine deposits and alluvium where it is discharged at springs.

Texas Springs water is collected by two french drain collection galleries within a tunnel located approximately 175 feet upstream from the station (**Figure 3**). Spring water from the french drains is conveyed into a narrow concrete channel that runs through the tunnel. Prior to exiting the tunnel at the door (**Figure 4**), spring water in the concrete channel is routed into a pipe and then downslope, underneath the service road, to the station measurement box (**Figure 5**). In September of 1999, a second line was added (**Figures 6 & 7**) to carry spring water from one collection gallery through a 4.5-inch pipe that runs alongside the concrete channel (**Figure 8**) and then underground to the measurement box due to fecal coliform contamination in the original concrete channel. The two separate 4.5-inch pipes that carry spring water from the collection galleries join together just before reaching the measurement box.

At the measurement box, Texas Springs flow is measured in a 3-inch cutthroat (Parshall) flume at the station and water is then routed away from the station through an ephemeral channel to a nearby riparian vegetation area. Prior to January 2001, when flooding occurred at the station, spring water was routed downstream to a 2-million gallon water storage tank that served as a potable water supply for the Furnace Creek area and overflow went to riparian vegetation. Presently, spring water is routed to riparian vegetation after discharge is measured in the flume and no water is routed to the storage tank for potable water supply.

The climate of DEVA is arid and may be characterized as a rain-shadow desert climate. Summers are extremely hot and dry and the winters are mild. Average summer temperatures are about 100 °F and average winter temperatures are about 60 °F. Winter storms in the Death Valley region are usually low intensity and account for approximately 65 to 75 percent of the annual precipitation (Fenelon and Moreo 2002). In the summer, convective rainstorms are typical, as exemplified by the flood of August 2004. DEVA receives an average of only 2 inches of precipitation per year. The potential evapotranspiration rate in the area is about 150 inches per year.

Vegetation cover is generally sparse but is concentrated in areas where springs and seeps are located, such as the area surrounding Texas Springs. Water discharging from Texas and Travertine Springs supports riparian vegetation noted for at least eight endemic special-status species and a biologically and culturally significant mesquite bosque. Wetland and riparian areas associated with the springs are the most biologically diverse and rarest habitats in Death Valley.

Large amounts of ground water have been pumped from the regional flow system. Ground-water pumping to support irrigation and agriculture began as early as 1913. Between 1913 and 1998, about 90 percent of the ground water pumped was used for irrigation (Moreo and others 2003). Most of the pumping has occurred in the Amargosa Desert, which is upgradient of Texas Springs, and in Pahrump Valley. Mining, public water supply and commercial use accounted for about 8 percent of the pumpage, and domestic use accounted for about 2 percent (Moreo and others 2003).
Major ground-water development is proposed to support growing urban areas like Las Vegas, NV and Pahrump, NV. Because surface water is seasonal and not a dependable water source for development, ground-water resources are being used to support growing urban demands. Ground-water pumping has the potential to deplete aquifer storage and reduce spring discharge.

CHANNEL AND CONTROL

The control for Texas Springs station is the crest or throat of the flume (**Figure 9**). The flume at Texas Springs is a cutthroat flume, which is similar to a Parshall flume except that it lacks a downstream diverging section or spillway crest (Plasti-Fab 2003). The dimensions of the flume at Texas Springs station are 3-inches by 2.75-feet (**Figure 10**). The crest/throat of the flume is set at the point of zero flow (PZF), which is 1.0 foot on the staff plate. The PZF serves as a control for the station and as the gage datum for surveys. The rating for a free-flowing Parshall flume is valid for a cutthroat flume if water *falls* from the end of flume, such as it does at Texas Springs (Skogerboe 1977). After discharge is measured in flume, spring water is routed away from the station to nearby riparian vegetation through an ephemeral channel.

GAGE

Discharge at Texas Springs station is channeled through a straight concrete trough and measured by diverting flow through a flume (**Figure 10**). The concrete channel leading to the flume is approximately 7.7 feet by 0.9, including the outer concrete side walls the channel dimensions are 7.7 feet by 2 feet in width and a depth of 5 feet. The dimensions of the flume are approximately 2.75 feet by 3-inches. The dimensions of the throat of the flume, also referred to as the crest, are 3 inches by 0.9 feet. **Figure 11** shows the engineered design of the Texas Springs station. **Figure 12** illustrates the location of the Texas Springs station in relation to other developed areas in the Furnace Creek Wash. Spring flow is fairly turbulent upon entering the concrete channel (trough no. 1) from the 6-inch inlet pipe, yet becomes more laminar further downstream. Instrumentation includes a Stevens GS 98 data logger with a shaft encoder and a Stevens F chart recorder and float (**Figure 13**). The serial number of the Stevens GS 98 data logger is 163187B and the site ID is number 3, both of which are included in the data recorded by the data logger. There is a vertical staff gage (0.00 to 3.32 feet) attached to the side of the stilling well that serves as a reference for the gage (**Figure 14**). Data logger instrumentation is located in a collection box over the stilling well attached to the flume (**Figures 15 & 16**). All instrumentation at Texas Springs, including the flume, stilling well and data logger are housed in fiberglass casing (**Figures 17 & 18**). The data logger records unit values (gage height measurements) in 15-minute intervals and the chart recorder provides a continuous record of gage height measurements. Each increment on the chart represents 12-hours.

The rating equation for the flume is:

$$Q = 0.992 * G^{1.547}$$

where Q = discharge in cubic feet per second (cfs) and G = gage height in feet.

Gage height is the only parameter that is recorded and it is logged every 15-minutes. Calendar year folders were created in years, 2002, 2003, 2004 and 2005 and all provisional data for years, 1989- 2001 were reported in calendar year format to report flow to the state of California. All finalized data (1989 – 2001) and records following the calendar year folder 2005 will be reported by water year.

HISTORY

The station has remained at its original location since its establishment.

Prior to 1941	Pacific Coast Borax Company built a tunnel to convey water through a pipeline to the Texas Springs station.
1977	Plans for Texas Springs flume design completed by NPS - Denver Science Center.
June 5, 1978	Texas Springs station established. Station consisted of flume and stilling well.
December 10, 1980	USGS installed the staff gage and conducted the first gage level survey.
1989	Monitoring program at Texas Springs agreed to by NPS and St. Joe Bullfrog Inc. (predecessor to Barrick Bullfrog) as a condition attached to several water right permits.
August 1989	Stevens F chart recorder was installed over the stilling well (**Figure 19**).
August 31, 1989	LOTUS 1-2-3 software program used for Texas Springs station data processing.

March 18, 1990	A Stevens shaft encoder and type A/F Stevens data logger were added to the station.
1991	Monitoring program at Texas Springs agreed to by NPS and U. S. Department of Energy (DOE) to address NPS concerns regarding proposed ground-water development up-gradient of DEVA.
June 28, 1992	Landers earthquake occurred in California (Fenelon and Moreo 2002)
June 29, 1992	Little Skull Mountain earthquake occurred ~30-km southeast of Yucca mountain (Lohman et al. 2002)
January 25, 1995	Tunnel that houses channel conveying spring water to station collapsed.
January 7, 1998	Microsoft Excel 5.0 software used for Texas Springs station data processing. LOTUS 1-2-3 software no longer used for data processing.
April 1999	Microsoft Excel 7.0 software used for Texas Springs station data processing. Microsoft Excel 5.0 no longer used for data processing.
August 13 - 24, 1999	No Texas Springs discharge data collected because flume flow was re-routed due to fecal coli form contamination detected in water distribution system.
September 3 – 26, 1999	No Texas Springs discharge data collected because flume flow was re-routed due to fecal coli form contamination detected in the water distribution system during routine water quality testing by maintenance staff.
September 1999	A second line was added to the Texas Springs tunnel. (Reference: "Draft Memo from WRB to DEVA. Prepared by Chris Gable and Jeff Albright. April 26, 2002.")
December 10, 1999	A Stevens GS 98 data logger was installed to replace the A/F data logger.
May 24, 2000	Steel lids replace aluminum lids over approach to flume.
October 25, 2000	Texas Springs station was taken off line due to fecal coliform contamination and presence of dead rats in tunnel.
January 2001	Texas Springs is no longer used as a potable water source and is not diverted to the 2-million gallon storage tank, but only to the riparian vegetation.
February 9, 2001	Texas Springs station monitoring resumes after maintenance interruption.
February 9, 2001	Fiberglass box installed over stilling well to house equipment at Texas Springs station.
June 2001	Barrick Bullfrog Inc. closed their mining operation. NPS is no longer providing Barrick Bullfrog Inc. with data from Texas Springs station.
January 1, 2002	ADAPS software used for Texas Springs station data processing. Microsoft Excel 7.0 Software no longer used for data processing.
September 26 – October 23, 2006	Park staff worked on water system to decrease the fluctuations in the water level by disconnection of line two and the sealing of leaks around the outflow pipe. See field note form for September 2006 in Water Year 2006 folder.

REFERENCE AND BENCHMARKS

Reference marks have been established and regularly surveyed at the station for elevation control (**Figure 10**). **Table 1** provides surveyed elevations of the flume's crest at the Texas Springs station. A complete listing of gage level survey results can be found in "Section 4: Summary of Gage Levels" of the Texas Springs History folder.

DATE	AGENCY	NAIL @ 3.2 FT ON STAFF (POINT 1)	THROAT/CREST BOTTOM – POINT OF ZERO FLOW (PZF) (POINT 4)	THROAT/CREST LEFT BANK, TOP (POINT 5)	THROAT/CREST RIGHT BANK, TOP (POINT 6)
12/10/1980	USGS	-	1.00	3.00	3.00
4/18/1994	NPS	3.20	0.98	-	-
5/07/1996	USGS	3.20	1.00	3.00	2.98
6/5/1996	NPS	3.20	0.98	2.98	2.98
4/11/1997	NPS	3.20	1.03	3.04	3.03
5/1/1998	NPS	3.20	1.00	3.00	3.00
4/16/1999	NPS	3.20	0.99	3.00	2.98
12/7/2000	NPS	3.20	0.99	3.00	3.00
10/25/2001	NPS	3.21	1.00	2.01*	2.01*
11/6/2002	NPS	3.20	1.01	3.00	2.99
10/20/2004	NPS	3.20	1.00	3.00	2.99

- Data not collected.

* Rod possibly read incorrectly by new technician.

Table 1: Surveyed elevations for Texas Springs station.

DISCHARGE MEASUREMENTS

Discharge from Texas Springs is channeled through a concrete trough and measured in a flume. Discharge for the site is calculated using the rating equation for the flume, however discharge measurements have been taken to confirm the rating and check calibration of the flume. A sketch of the discharge measurement site for the station is illustrated in **Figure 20**. The discharge measurement site is located about 1.0 foot upstream from the beginning of the converging walls leading to the flume. The staff gage and stilling well are located along the converging walls of the concrete trough just before the flow reaches the throat of the flume.

Discharge monitoring at the Texas Springs station is described in more detail in a memo addressed to Chris Gable (NPS-WRB) from Richard LaCamera (USGS) dated December 13, 1994 located in "SECTION 6: CORRESPONDENCE AND MISCELLANEOUS SUPPORTING MATERIALS" of the Texas Springs History Folder.

HIGH FLOWS

The highest daily mean discharge for the Texas Springs station was 0.48 cfs measured on June 5, 1996 (Period of Record: September 1, 1989 – September 30, 2006). The range of daily mean discharge values is 0.40 cfs (minimum, diverted) to 0.48 cfs (maximum), with the mean being equal to 0.44 cfs. See **Figure 21** for a plot of the daily mean discharge for Texas Springs for 1989 through 2006.

The highest discharge measured for Texas Springs was 0.57 cfs measured on November 16, 1993 by the USGS. (The actual maximum discharge measurement of 0.64 cfs measured by the USGS on January 27, 1992 was not valid because the measurement was made inside the tunnel, not at the approach to the flume. Therefore, this measurement is not comparable to the others.)

The flow from Texas Springs is relatively stable and does not fluctuate with storm events.

POINT OF ZERO FLOW

The point of zero flow (PZF) for the Texas Springs station is 1.0 foot and is located at the crest/throat of the flume (**Figure 10**). The PZF is surveyed regularly as part of the gage levels survey.

WINTER FLOW

Texas Springs flow is relatively consistent and does not vary in the winter.

REGULATION AND DIVERSION

The NPS diverts all of the Texas Springs flow directly downstream of the station to the surrounding riparian vegetation. No other diversions are imposed on the flow from the springs.

ACCURACY

The discharge record for Texas Springs from the flume is considered excellent. The Plasti-Fab flume is installed in concrete and level surveys (Summary of Levels, Section 4 of the History Folder) indicate the flume is stable and installed as recommended in the Water Measurement Manual, Bureau of Reclamation, U.S. Department of the Interior (2001).

The NPS and USGS performed manual discharge measurements with a pygmy current meter from 1990 to 2001 to verify the accuracy of the flume. However, we were unable to measure the 25 - 30 intervals normally required by the USGS due to the narrow width of the approach into the flume (Rantz 1982). Therefore, many of the manual discharge measurements were rated "poor." Differences between the discharges computed from the flume and USGS manual discharge measurements for 1990 through 1994 ranged from -19.4 to 17.8 percent (Section 2, shift analysis of the History Folder). Differences between flume discharge and NPS manual discharge measurements before November 1994 ranged from -9.3 to 11.1 percent. A special flow test was conducted by the NPS on November 30, 1994, to verify the rating of the flume at gage heights ranging from 0.3 to 0.6 feet. Differences between discharges computed from the flume and manual discharge measurements ranged from 2.0 to 24.2 percent for 6 measurements.

The NPS and USGS refined techniques November 1994 to improve the accuracy of the manual discharge measurements by improving depth measurements and applying a mean vertical velocity coefficient (.75) for the intervals next to the smooth vertical walls (Section 6, Correspondence with USGS, History Folder). All pre-November 1994 NPS and USGS manual measurements were recalculated to include the velocity coefficient. From 1995 through 2001, differences between discharges computed from the flume and NPS manual discharge measurements improved and ranged from -8.9 to 7.8 percent.

COOPERATION

The Texas Springs station is maintained by the NPS-WRB and DEVA staff. DEVA staff visit the station monthly to inspect data loggers, the chart recorder and collect data records. NPS-WRB processes and analyzes the data using ADAPS, collects periodic discharge and survey data, and provides QA/QC for all data collection and analyses.

The USGS has been a cooperator in monitoring Texas Springs station. USGS staff conducted two surveys for Texas Springs, including one on December 10, 1980 and one on May 7, 1996.

LOCAL PARK PARTNER

Park Staff Contacts:

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